PATENT SPECIFICATION

(11) 1330458

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NO DRAWINGS

(21) Application No. 4781/71 (22) Filed 16 Feb. 1971

(23) Complete Specification filed 15 Feb. 1972

(44) Complete Specification published 19 Sept. 1973

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(19) THE PATENT OFFICE LONDON

(54) MAKING LIGHT WEIGHT CONCRETE

(71) I, CHARLES WILLIAM BRABAZON URMSTON, a British subject of 9, Thurloe Street, London, S.W.7., do

Where it is desired to reduce the density of the concrete even further than by the above methods (a) and (b), it is common practice

PATENTS ACT 1949

SPECIFICATION NO 1330458

The following amendments were allowed under Section 29 on 24 July 1979

Page 2, lines 19 and 20, page 5, lines 23 and 24, *delete* cementitious material *insert* Portland cement
Page 2, line 21, *after* mix first occurrence *insert,* the material for aerating the mix including aluminium powder, alkali, catalyst and soap which are introduced to the mix in the water, the water temperature being in the range 35° to 75°C
Page 2, lines 28 and 29, page 5, lines 35 and 36, *delete* closure which allows gas but not solids to *insert* perforated rigid closure over the whole area of the top of the mould and filter material under said closure whereby gas and liquid but not solids can
Page 2, lines 34 and 35, *delete* which may by in the range 35° to 75°C and is
Page 3, line 90, *delete* "additive" *insert* activating agent
Page 4, *delete* lines 18 and 19
Page 4, line 20, *delete* but preferably *insert* Preferably
Page 5, line 25, *after* mix *insert,* the material for aerating the mix including aluminium powder, alkali, catalyst and soap which are introduced to the mix in the water, the water temperature being in the range 35° to 75°C
Page 5, *delete* lines 40 to 46
Page 5, *for* claims 4 to 7 and 9 to 12 *read* 2 to 5 and 6 to 9
Page 5, lines 47 and 48 *delete* 2 or Claim 3 *insert* 1
Page 5, lines 54 and 58, *for* 4 *read* 2
Page 5, line 62, *delete* 4 to 6 *insert* 2 to 4
Page 5, *delete* lines 64 to 67
Page 5, lines 68 and 69, *delete* Claim 8, wherein the mould has a lid consisting *insert* any of the preceding claims wherein the mould closure consists

THE PATENT OFFICE
25 September 1979

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further processing. This involves machinery as well as labour.

(e) In normal aeration processes, such as in Patent 648,280, it is not possible to

SPECIFICATION AMENDED - SEE ATTACHED SLIP

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(54) MAKING LIGHT WEIGHT CONCRETE

(71) I, CHARLES WILLIAM BRABAZON URMSTON, a British subject of 9, Thurloe Street, London, S.W.7., do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to light weight concrete, which may or may not be reinforced.

There are a number of ways of making concrete lighter. The degree to which this can be done is dependent on the method used. The following methods are known:—

(a) "No-fines" concrete wherein a certain reduction in weight is obtained by leaving out the "fines" from the coarse aggregate and cement mixture, thus leaving voids in the concrete the general effect of which is to reduce its weight, from 150 lbs. per cubic ft. to approximately 135 lbs. per cubic ft.

(b) By the introduction of lightweight aggregates in place of the heavy stone and gravel aggregates commonly used. The extent to which the weight of the resulting concrete is reduced is relative to the weight of the replacement lightweight aggregate. Examples of lightweight aggregate are pumice, foamed slag, furnace clinker, expanded clay, slate or slate and sintered pulverized fuel ash.

By these methods the density range is somewhere between 140 bs. per cubic ft. down to 70 lbs. per cubic ft. nominal density.

No departure from standard techniques is involved: the ingredients are added in normal cement mixers and the concrete placed in the normal way and vibrated to obtain the correct degree of compaction.

Lightweight structural concrete made by the above methods has the advantage that it can be poured to virtually any height within moulds or shutters without any detrimental effect. This has a particularly useful application in the pouring of storey high partitions in vertical casting in gangs of vertical panel moulds.

Where it is desired to reduce the density of the concrete even further than by the above methods (a) and (b), it is common practice to introduce air either as a preformed foam or by using chemical foaming agents such as aluminium powder in conjunction with an alkali. By such methods it is possible to produce lightweight concrete with a density of 30 lbs. per cubic ft. to 75 lbs. per cubic ft. Preferred methods of making aerated concrete are described in British patent specifications 1,040,442, and 648,280: these methods enable the effective use of aggregates, both of normal and lightweight type.

As has been described, there are no problems in making concrete lighter by replacing the heavy aggregates with lightweight aggregates and the like. There are, however, a number of disadvantages and problems which arise when attempts are made to produce a lighter concrete by the process of introducing air and a gas. These can be summarised as follows:—

(a) It is not possible to cast a material beyond a certain depth generally only about 2 ft., without the concrete setting non-homogeneously, with the result that it is useless.

(b) Owing to the expansion of the mass around any reinforcement present a gap tends to be left at the top of the reinforcement as the material rises around it, which is commonly known as 'shadow' which either destroys or greatly reduces the bond strength between the reinforcing steel and the concrete, thus limiting its performance and uses.

(c) It is a technically difficult problem to obtain homogeneity throughout the mass.

(d) Owing to the material rising like a loaf of bread in manufacture, a top crust of a scummy or aerated nature remains which has to be removed prior to further processing. This involves machinery as well as labour.

(e) In normal aeration processes, such as in Patent 648,280, it is not possible to

SPECIFICATION AMENDED - SEE ATTACHED SLIP

incorporate coarse aggregate satisfactorily as owing to the fluid state of of the mass necessary prior to pouring into the moulds, the aggregate either floats to the top or sinks to the bottom but does not stay well and evenly distributed.

The process described in the patent 1,040,422 mentioned obviates the disadvantage (e) and minimizes the others.

In one important aspect the invention aims to minimize the disadvantages (a) to (d) and in particular to enable casting of aerated concrete to a greater depth than has been possible heretofore.

With this aim in view, the invention provides a process of producing lightweight concrete units which comprises the steps of:—

Making a mix including cementitious material, aggregate, water and material for aerating the mix; inserting the mix into a mould and allowing the mix to set into a block in the mould, and stripping the mould and autoclaving the block, wherein the mix is inserted into the mould before the aeration of the mix is completed and without completely filling the mould, the mould is provided with a closure which allows gas but not solids to escape, and the mix is allowed to expand to fill the mould and set under pressure produced by its own aeration.

Preferably the mix is made by first introducing into the water at a predetermined temperature, which may by in the range 35° to 75°C and is preferably about 65°C, aluminium powder of the type known as 'atomised' together with alkali and a catalyst and soap, all in predetermined amounts. The atomised aluminium powder is preferably of the size known as "120 dust" and sold by Alcan Industries Limited. The water is then immediately introduced into the aggregate and cement.

A further important aspect of the invention is concerned with the use of coarse aggregate, preferably of lightweight type in aerated concrete.

It will be recalled that ordinary aerated concrete processes, though not that of patent 1,040,442, cannot make use of coarse aggregate satisfactorily. Quite apart from the reason given at (e) above, there is a further difficulty hindering what might have been regarded at first sight as the natural step of combining lightweight aggregate and aeration in concrete, as will now be explained.

As above mentioned, lightweight aggregate concrete units are normally made by conventional concrete techniques, with mixes of moderate slump, vibrated, tamped or pressed into the individual moulds of the dimensions of the required unit, whether of block, slab or beam type. Aerated concrete, on the other hand, has to be cast as a fluid mix so that it can "rise" in the mould as the gas is generated.

Since all aerated concrete is now hardened in high pressure steam in large autoclaves and use of a large number of individual moulds would generally be quite uneconomic, it is necessary to form the material in very large moulds and cut it up after setting into the required size and shape.

In the past this has commonly been done after the material has expanded and set, but while still in a soft condition and before hardening in the autoclaves. The cutting is done by multiple wires while the cake is still on the base of the mould. Since there are no coarse particles and no aggregates in the ordinary aerated concretes, this can be done easily, the cutting action being comparable to that of cutting cheese.

Where it is desired to have aerated concrete with course aggregate, a similar fluid consistency would still be necessary and for economic and technical reasons, it would still be essential to pour into large moulds. However, it would be impossible to cut up the cake in the same way while still in a soft condition, since the coarse particles would drag with the wires and destroy the structure.

The present invention overcomes the difficulty in that the concrete can be homogeneous up to heights of ten feet and thus large panels can be made as integral castings, which was not hitherto possible.

If desired, however, the concrete can be formed as a block, and sawn after being autoclaved, which obviates cutting by wires when the block is soft. The mix is preferably made as before described, the mixing water, with its charge of aluminium, alkali, catalyst and soap, being immediately introduced into the fine aggregate and cement, and shortly after, say after a minute or a minute and a half, when the aeration has brought the mix to an appropriate state to support it, the coarse lightweight aggregate is added. This may be of $\frac{3}{4}''$ to $\frac{1}{4}''$ size and up to 60lb./cu. ft. bulk density, though higher densities can be used if the sizes are reduced. With little further mixing, sufficient to achieve homogeneity but before the aerating action has ceased completely, the mix is poured.

The following are examples of mixes which may be used in carrying out the invention:—

Example A

Ingredients	Amounts
Cement	127 lbs
Fly ash	165 lbs
Sintered fly ash aggregate pellets	254 lbs
Activating agent (as below)	256 grms
Water at 65°C	16 gallons

The mixing time was 2 minutes, and the set volume 10 cu. ft. The density of the product was 60lbs/cu. ft.

Example B

Ingredients	Amounts
Cement	127 lbs
Fly ash	165 lbs
Sintered pellets	254 lbs
Activating agent (as below)	110 grms
Water at 62½°C	15.4 gallons

The mixing time was 2 minutes, and the set volume 8 cu. ft. The density of the product was 75lbs/cu. ft.

Example C

Ingredients	Amounts
Cement	158 lbs
Fly ash	260 lbs
Sintered fly ash pellets	318 lbs
Activating agent (as below)	320 grms
Water at 60°C	25.8 gallons

The mixing time was 2 minutes, and the set volume 10.5 cu. ft. The density of the product was 65 lbs/cu. ft.

Example D

Ingredients	Amounts
Cement	130 lbs
Sintered fuel ash	80 lbs
Fine sand	92.5 lbs
Fly ash	69 lbs
Sintered fly ash pellets	172 lbs
Activating agent (as below)	145 grms
Water at 62½°C	18.5 gallons

The mixing time was 2¾ minutes, and the set volume 8 cu. ft. The density of the product was 70 lbs/cu. ft.

Example E

Ingredients	Amounts
Cement	75 lbs
Ash	125 lbs
Clay pellets	30 lbs
Activating agent (as below)	100 grms
Water at 63°C	12 gallons

The mixing time was 2½ minutes, and the set volume 4 cu. ft. The density of the product was 62 lbs/cu. ft.

Example F

Ingredients	Amounts
Cement	112 lbs
Ash	145 lbs
Clay pellets	120 lbs
Activating agent (as below)	75 grms
Water at 65°C	12 gallons

The mixing time was 3 minutes, and the set volume 6 cu. ft. The density of the product was 65 lbs/cu. ft.

Example G

Ingredients	Amounts
Cement	86 lbs
Ash	121 lbs
Clay pellets	120 lbs
Activating agent (as below)	75 grms
Water at 60°C	12.5 gallons

The mixing time was 2 minutes, and the set volume 5 cu. ft. The density of the product was 65 lbs/cu. ft.

The "additive" above referred to in the examples is in each case made up as follows:

	Parts by weight
Aluminium (atomised powder)	10
Sodium carbonate	17.5
Sodium stearate	2
Ferric oxide	10

In the Examples the set volume and density refer to the filled mould. There is no waste. In the Examples given in Patent

1,040,422 the set volume and density are referred only to the usable portion of the block, after the dross is cut off.

As proposed in specification 1,090,261, the cement can be "micron-sized" with reduction of quantity recommended in that specification.

In the usual case where the mix is poured into open moulds, to control the pressure developed in the mould to be appropriate for a given height of mould, pouring the mix into the mould is stopped with the mix at a specific distance from the top. A lid is then immediately closed on the mould tight enough to prevent the concrete from coming out, but such that the trapped air can vent as the concrete expands.

Simply to bolt on a mould lid without provision for gas or water tightness may suffice, but preferably the mould lid consists of perforated wood, metal or plastics plates with holes of approximately $\frac{1}{4}'' \times \frac{3}{4}''$ and a filter paper or other semi-porous material held in place thereby. By these means it is possible for the excess pressure and water to be expelled from the mix so that (a) the mould does not burst and (b) the maximum water comes out through the filter media via the holes in the supporting mould lid with greatly enhanced benefits to the properties of the product. If desired other parts of the mould besides the lid can be made perforated.

The removal of excess water is most valuable for this reason—it is known that the water/cement ratio is critical in all concrete work. In order to get the mix to flow adequately a given quantity of water has to be used, both in normal dense concrete and more particularly in aerated concretes and in such concretes using lightweight aggregate. The minimum water for adequate fluidity of the mix is greater than is absolutely necessary for hydration. It is known in the industry that particularly in the production of dense concrete slabs (e.g. paving stones) it is possible to get rid of this excess water by applying a very high pressure in a press, which increases the concrete density. In this preferred feature of the invention some excess water is removed from the concrete by the pressure developed by its own aerations without increase of density.

The concrete expands in the mould due to the effect of the aluminium powder reaction until the mould is filled: this occurs at a point considerably before expansion would have stopped if the mould had been open. This final expansion is resisted by the strength of the mould so that the whole mass is put under pressure. The amount of pressure is determined relative to the desired final density of the material and the height to which it has to be poured. The time of pouring the mix (i.e. the amount of aeration still left), the depth to which the concrete is poured and the arrangement used to allow gas and water to escape will be determined empirically.

The selection of the aluminium powder and other chemicals, and the temperatures used in the process are such that a very fast expansion is achieved in the mixer in order to make it possible to support the aggregates and also to make it possible to achieve before pouring the mix such a high percentage of the total expansion that the mould can be filled to a greater depth than is possible in hitherto standard aerated concrete techniques. The final expansion then develops pressure in the mould and this continues for longer than usual with standard techniques in open moulds so that the pressure is kept up within the mould until the material has set, thus improving the bond between the material and any reinforcing steel, and also between the fine material and the coarse aggregates. Without this final expansion there would be a tendency for the material to retract from the lid; if this happens to any extent the product is rendered useless.

In the preferred embodiment of the invention above described the concrete is poured from the top into moulds, which are subsequently closed. If desired, the concrete can be pumped into a closed mould, e.g. from the bottom, much as plastics is injected in the injection moulding technique.

The following benefits are achieved by the process described:

(a) Since the concrete can be homogeneous up to heights of 10 feet, large unitary panels can be made which hitherto would have to be made, if at all, out of a number of individual "planks" joined together.

(b) In the normal aerated concrete considerable technical difficulty and much expertise is required to obtain a constant density to produce a homogeneous material even in moulds up to two feet deep. It is necessary to remove the top several inches from the cast material after it has set. The method just described improves homogeneity, even over much greater depth, and obviates the need for cutting off the top of the cast material.

(c) A known weight of material is placed in the mould, there is no wastage, and the final density of the material is entirely predictable.

(d) Vibration is unnecessary: the pressure generated in the mass compresses the material tightly around any reinforcing steel present, giving a good bond with the steel reinforcement, in contrast to the ordinary aerated lightweight concrete where the expansion around the steel upwards produces what is commonly referred to as shadow effect, i.e. a gap between the top of the reinforc-

ing steel and the material which seriously reduces the bond strength of the material with any reinforcing steel. The compression of the material around the reinforcing rods also helps to resist corrosion of the steel.

(e) The pressurising of the concrete in setting is effective in increasing the bond strength between the material and any steel reinforcement, but it has the same effect in compressing the material into and round the lightweight aggregate which tends to improve the physical properties of the concrete. Furthermore, where it is desired to profile or cast a pattern for decorative or other reasons into the unit the expansion under pressure ensures a clear cut and accurate result.

WHAT I CLAIM IS:—

1. A process of producing lightweight concrete units which comprises the steps of:

making a mix including cementitious material, aggregate, water and material for aerating the mix;

inserting the mix into a mould and allowing the mix to set into a block in the mould, and

stripping the mould and autoclaving the block,

wherein

the mix is inserted into the mould before the aeration of the mix is completed and without completely filling the mould,

the mould is provided with a closure which alows gas but not solids to escape, and

the mix is allowed to expand to fill the mould and set under pressure produced by its own aeration.

2. A process as claimed in Claim 1, wherein the mix includes aluminium powder, alkali, catalyst and soap to effect aeration, which are introduced to the mix in the water.

3. A process as claimed in Claim 2, wherein the water temperature is in the range 35° to 75°C.

4. A process as claimed in Claim 2 or Claim 3 using fine and coarse aggregate, wherein the water is immediately introduced into the fine aggregate and cement and then after aeration of the mix has begun, the coarse aggregate is added further mixing being only such as to achieve homogeneity.

5. A process as claimed in Claim 4, wherein the coarse aggregate is of lightweight type in the $\frac{3}{4}''$ to $\frac{1}{4}''$ size and up to 60 lb./cu. ft. bulk density.

6. A process as claimed in Claim 4, wherein the mix conforms to any one of the examples A to G given above.

7. A process as claimed in any of Claims 4 to 6 wherein the block is sawn after it has been autoclaved.

8. A process as claimed in any of the preceding Claims, wherein the closure is such that not only gas but also water can be expelled from the mould.

9. A process as claimed in Claim 8, wherein the mould has a lid consisting of perforated plates supporting filter paper or other porous material.

10. A process as claimed in any of the preceding Claims, wherein the mix is poured by injection into the mould from below.

11. A process for producing lightweight concrete units substantially as herein described.

12. A concrete unit produced by the process of any of the foregoing Claims.

TREGEAR, THIEMANN & BLEACH,
Chartered Patent Agents,
Agents for the Applicant(s),
Melbourne House,
Aldwych,
London, W.C.2.

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